The Delta Smelt Individual-based Model in R

The delta smelt individual-based model in R (IBMR) tracks the growth, survival, reproduction, and movement of simulated individuals in the Sacramento-San Joaquin Delta, given observed or predicted zooplankton abundance and spatial distribution, the spatial distribution of delta smelt, Old and Middle River flow, water temperature, and Secchi depth. For a full mathematical description of the model, please see the "IBMR documentation". This README files provides instructions for the use of the R code to execute the model.

The IBMR code consists of six executable .R files: 'Delta smelt data functions_v2_4', 'IBMR_parameters_v2', 'IBMR_pop.model_v2.4', 'IBMR_control.model_v2.4', 'IBMR_graphs_v2', and 'IBMR_get summaries and save_v2.2'. Also included in the package are several raw data files that will not be enumerated here. The only files that need to be opened and executed in order to run the model and see summaries of the results are IBMR_control.model, IBMR_graphs, and IBMR_get summaries and save. Delta smelt data functions opens raw data files and summarizes them into the dimensions required for IBMR data, and IBMR_parameters contains the bioenergetics model parameters described in the original model description by Rose et al. (2013). IBMR_pop.model contains the bioenergetics and population model. If the user chooses to modify IBMR data, parameters, or the population model, extreme care should be taken when editing Delta smelt data functions, IBMR_parameters, or IBMR_pop.model, because errors in any of these files may cause IBMR to fail to execute.

Control model file

IBMR_control.model calls Delta smelt data functions, IBMR_parameters, and IBMR_pop.model, and runs the model. The first few lines of IBMR_control.model contain a filepath to the working directory where all IBMR files are stored. Each user should edit this line to be consistent with their own file organization structure. The next few lines delineate IBMR dimensions, where the length of the time series, number of simulated individuals, and number of simulated populations can be modified. Section 3 loads the executable files that summarize data and contain model parameters and the population model.

Section 4 of IBMR_control.model contains a series of flags that indicate whether new predictions for model data should be substituted for the observed Delta data. For a run of the base model using only observed data, each flag should be set to 'F'. The second half of Section 4 loads predicted data that describe changes to the biotic and abiotic conditions experienced by delta smelt, under a given simulated management scenario (e.g., an Old and Middle River flow limitation that was not part of the observed time series). Depending on how many dimensions are relevant for one of the five type of data driving IBMR, all data are in dimensions of year x month x spatial strata x prey type. New predicted data describing some change to observed conditions should take the form of a matrix or array with the above dimensions. If no change is expected for a given year x month x spatial strata combination, the matrix of predictions should include a 'NA'; otherwise, if a change to one the biotic or abiotic conditions is predicted, the matrix entry should contain the value of that prediction. The code is structured to skip NAs and substitute any new value provided. The final part of IBMR_control.model, Section 5, loops through each simulated population model by repeatedly executing IBMR_pop.model.

Get summaries and save file

Once all simulations are complete, run the full IBMR_get summaries and save file in order to summarize model results. Results are summarized into annual simulated population growth rates *lamAB*, and then *lamAB* are summarized into geometric mean population growth rates *lam.mn*, for the entire simulation. If the user desires, results can be saved by uncommenting (delete #s) Section 2 and updating the filepath under Section 2 appropriately.

IBMR graphs file

After summarizing results, several graphs can be produced with the IBMR_graphs file, including

-Observed versus simulated February lengths

-Histogram of population growth. Currently set to calculate the ratio of cohort 1999 to 2014 abundance

-IBMR simulated versus Life Cycle Model estimated abundance for four life stages

-Time series of IBMR simulated versus Life Cycle Model estimated population growth rates

-Time series of simulated entrainment rates versus OMR, for all entrained life stages

-Simulated versus observed spatial distributions